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Environmental
Regulation
vs.
Economic
Development

UTAH SCIENCE

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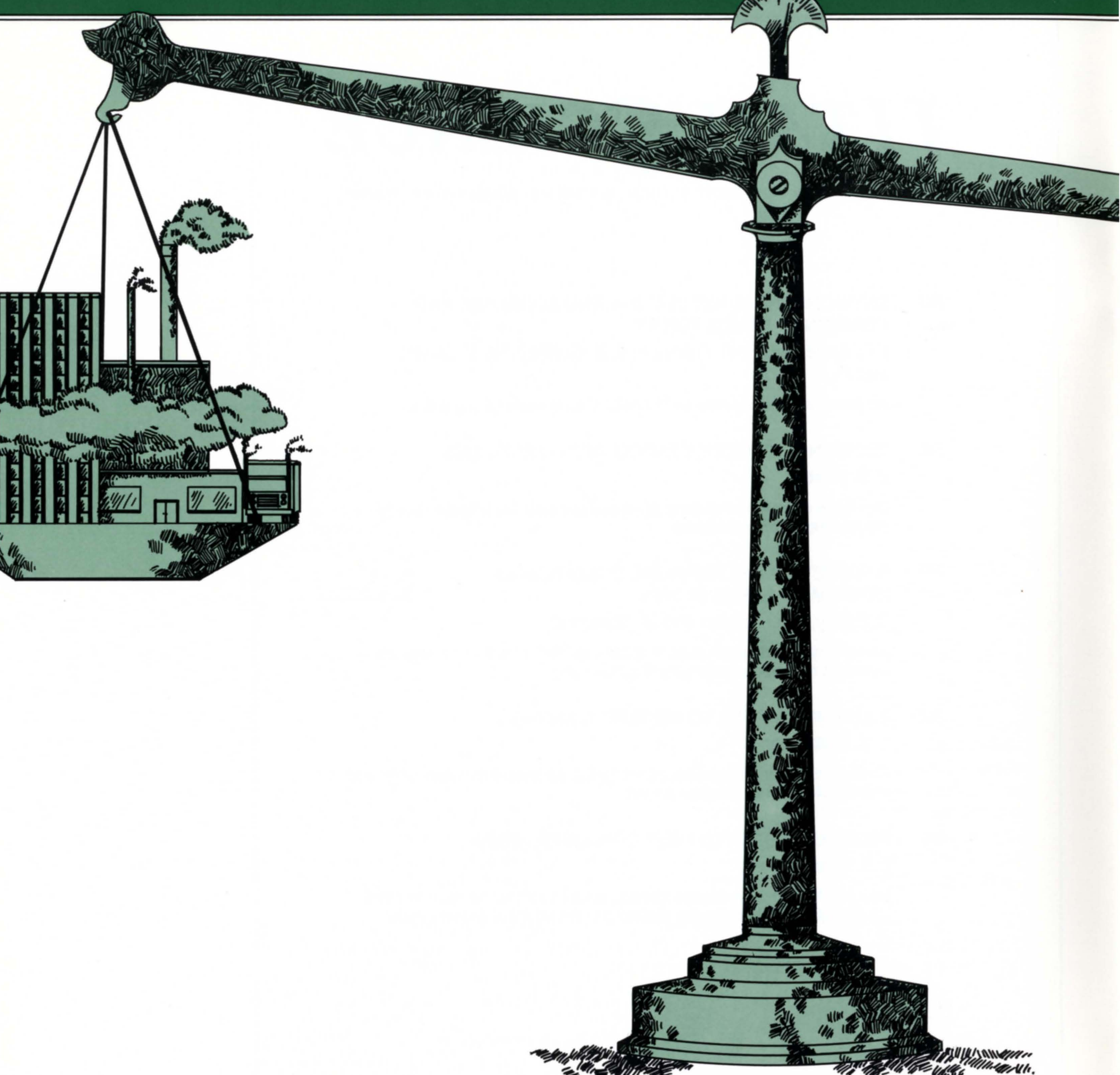
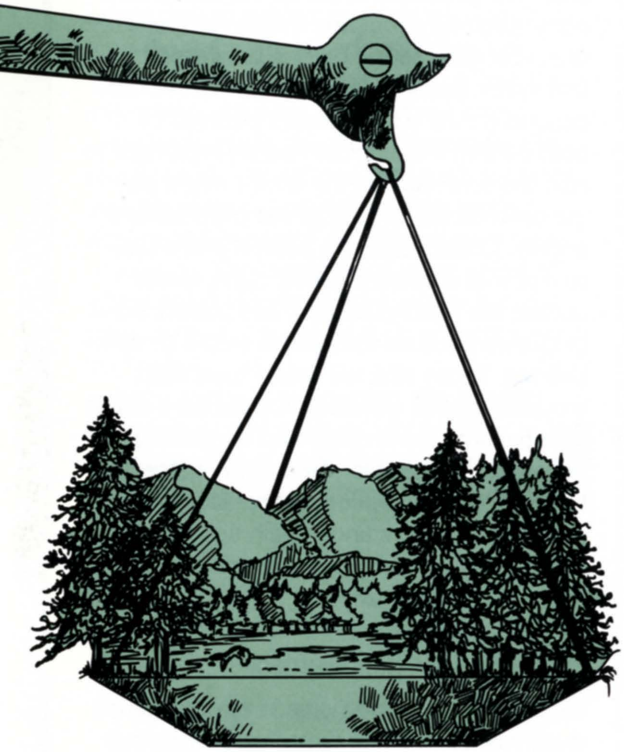


ENVIRONMENTAL REGULATION AND ECONOMIC AND COMMUNITY DEVELOPMENT

J. C. ANDERSEN, H. H. FULLERTON, E. B. GODFREY,
W. C. LEWIS and D. L. SNYDER



Introduction

Environmental controversies generally involve the failure of the market to efficiently allocate a scarce resource. Some of these resources include air, water, land, and "quiet." Decisions concerning the use of natural resources may result in side effects because they do not always consider how others will be affected, now and in the future. These side effects (also known as externalities, spill-overs, third-party effects, external economies and diseconomies), generally concern the decisions of individuals, businesses, households, or public agencies. At issue is the fact that some market transactions affect more parties than just buyers and sellers (Turvey 1971). In its simplest form, a side effect or external diseconomy occurs when individual A produces or consumes something that has a negative effect on individual B, but A does not compensate B for those negative effects.

External diseconomies are widespread and include the following examples:

Fishermen taking fish in a fishery increase costs for all other fishermen if the stock of fish is reduced.

Traffic congestion impedes other drivers and pedestrians.

New wells can lower groundwater levels, thus increasing pumping costs for all existing wells.

Noise from jets can affect households.

Industrial effluents discharged into rivers increase treatment costs for downstream water users.

Overhead power lines, smoke, and noise can destroy or diminish the beauty of natural features.

Toxic emissions may harm humans or animals and destroy property.

Thus, several types of market transactions (e.g., a purchase of an airline ticket, a teenager purchasing and operating a loud motorcycle) may impose costs or discomfort on others who are not directly involved in the transaction. This market failure is the rationale for public intervention in ordinary business affairs: the government intervenes to impose social costs on those responsible for the costs, costs which are not reflected in the market transaction.

However, the cost of establishing a mechanism to redress market failure may exceed the benefits associated with the action; thus intervention may or may not "improve" social welfare. Public intervention in market transactions is most warranted in highly dispersed activities that have substantial negative external effects, as with some forms of air pollution. Intervention is less warranted in transactions whose impacts are localized and that involve special interests (Stroup and Gwartney 1982). In short, the gain to society that results from the correction of market failures should exceed the total public and private costs of implementing these corrections.

From an Open to a Closed Society

Industrial development and population increases have contributed to the problem but are not solely responsible for the deterioration in the quality of the natural environment. For example, early explorers and settlers reported that valleys in Utah and the Los Angeles basin were thick with smoke and haze from the fires of the Indians. Poor environmental and health conditions in economically depressed rural areas demonstrate that the absence of industrialization does not necessarily foster a desirable environment.

In many less developed countries, forest areas have been denuded for fuel for heating and cooking, poor sanitary conditions predominate, water is unfit to drink, and the air is polluted. Thus, even though industrialization may generate pollution, it can also provide the means to correct other critical environmental problems.

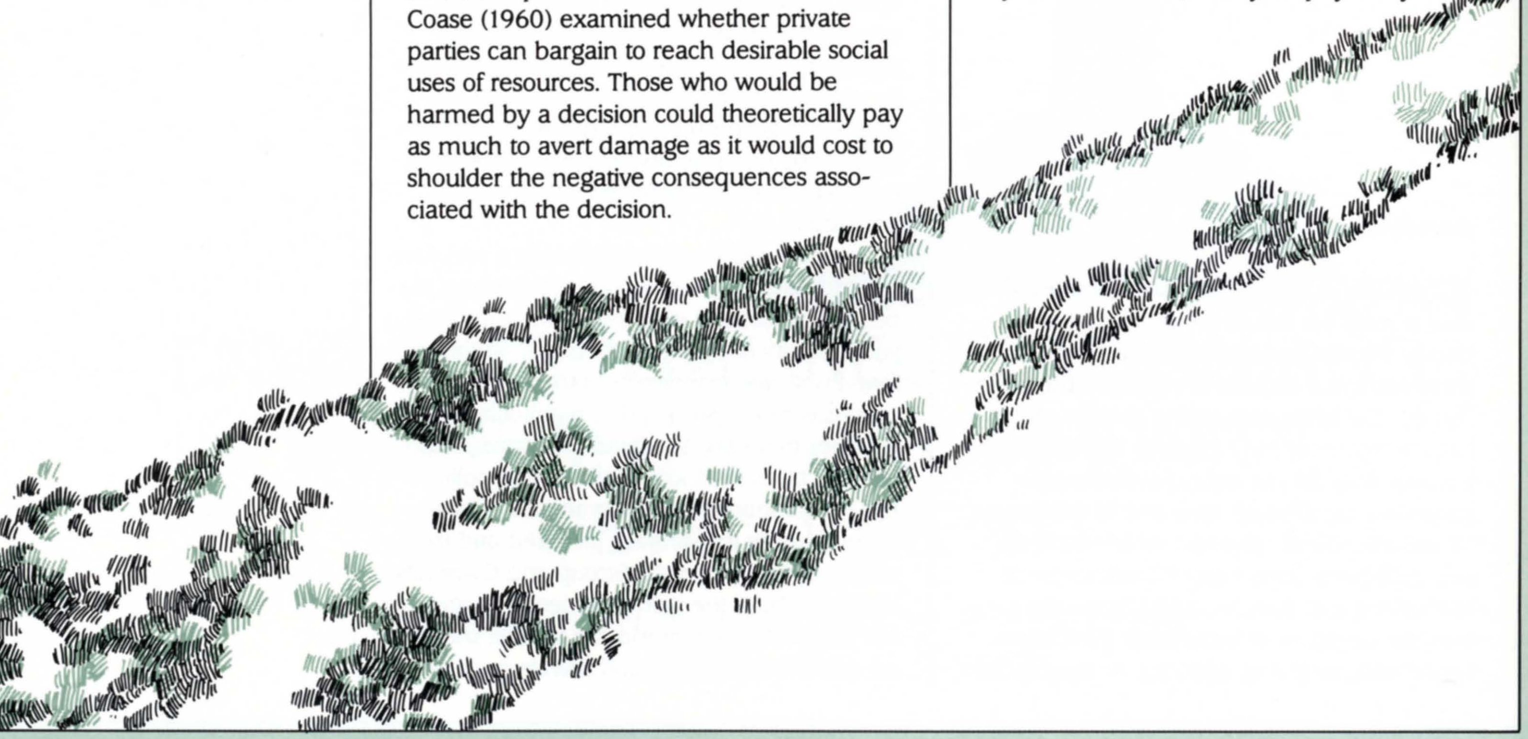
Boulding (1971) noted that we no longer have a "frontier" beyond the limits of habitation, an area that is less crowded, cleaner, or that offers a more fluid social structure. The sphere of human activity is closing, which means that we must live more in harmony with each other and with the natural environment.

As noted above, the social costs or benefits associated with resource use are not considered in private economic transactions. Coase (1960) examined whether private parties can bargain to reach desirable social uses of resources. Those who would be harmed by a decision could theoretically pay as much to avert damage as it would cost to shoulder the negative consequences associated with the decision.

For example, Coase cites a hypothetical case in which noise from a candy factory disturbed a physician who recently moved to the area. The physician could let the candy company continue to operate if they compensated him, erected a sound barrier, or moved him to another location. The best solution would depend on the relative losses incurred by both parties. If the doctor had no legal right to stop the confectioner, the doctor might pay the confectioner to change the objectionable activity. Coase's ultimate point is that a system of well defined property rights would obviate the need to identify and correct these inequities because the system would be self-policing. Those affected would have legal recourse against pollutors. Transactions of this type become more costly and bargaining becomes less feasible when many parties are involved. But bargaining is theoretically possible if those who stand to gain and lose from a change in resource use can be identified.

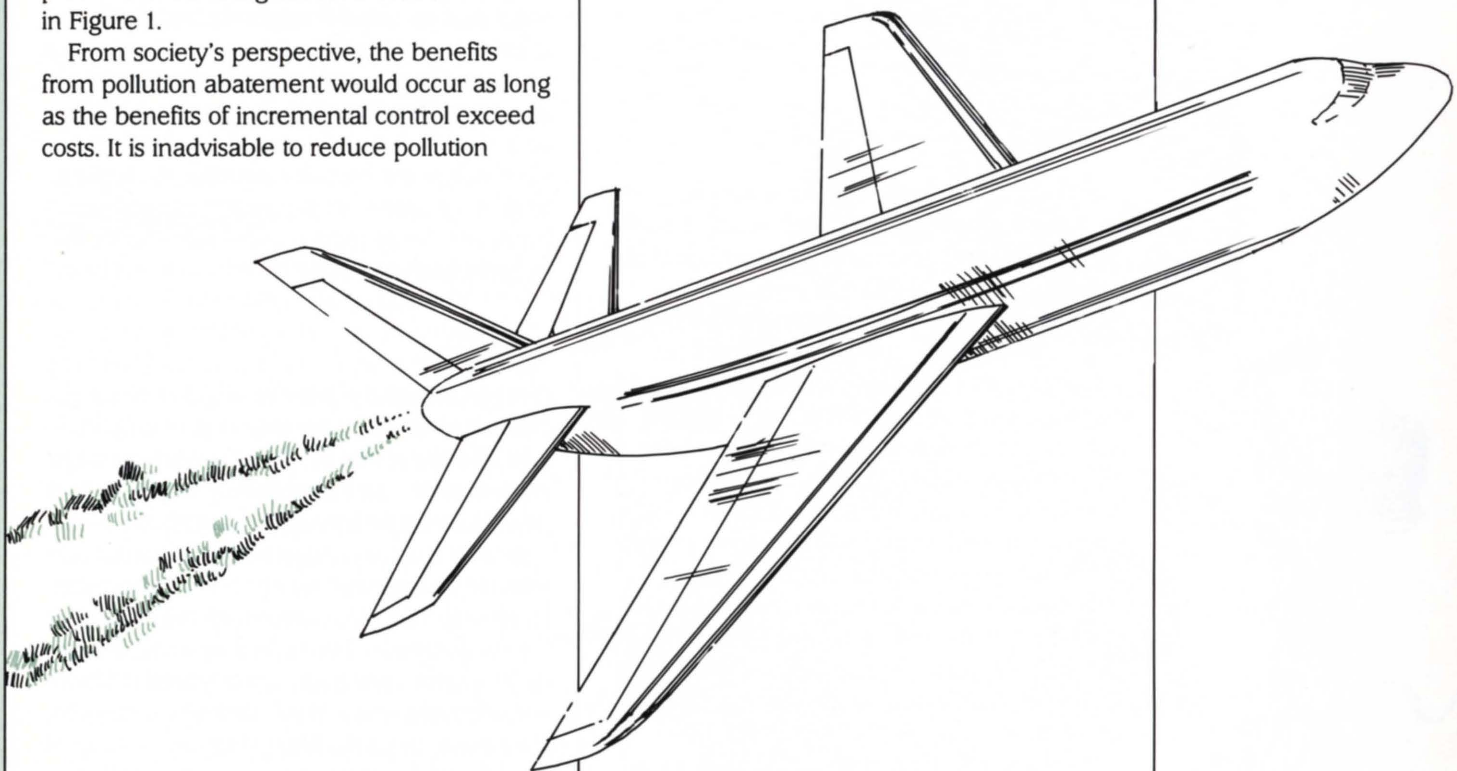
Benefits and Costs of Environmental Improvement

Incremental improvements in environmental quality become more expensive, somewhat analogous to wringing water from a towel. Simple and inexpensive measures can often solve major environmental problems, but solutions become increasingly expensive if a complete solution is attempted, such as removing the last millionth or billionth part of a pollutant. In fact, it may be physically



impossible to completely eliminate some pollutants. The costs of pollution reduction and the benefits of doing so are graphically shown in Figure 1. For example, a water quality improvement program may attempt to make the water sufficiently "clear" or "pure" for some intended uses (i.e., fishing, swimming, drinking, etc.) but not seek to completely purify the water. Generally, the social benefits associated with each successive unit decrease in pollution or attempting to remove the last trace of pollution may be of little value. The incremental value or benefit of improved environmental quality is compared with the marginal costs of such actions in Figure 1.

From society's perspective, the benefits from pollution abatement would occur as long as the benefits of incremental control exceed costs. It is inadvisable to reduce pollution beyond the point where the incremental costs exceed benefits. Thus, Figure 1 shows that control should proceed no further than point A. Controlling pollution to point B might mean paying two or three dollars for improved resource quality worth only one dollar. However, it may be difficult to ascertain the full extent of pollution-related damage and it is advisable to be particularly cautious when pollution might affect human health and safety or there is a potential for injury or irreversible resource damage. In these cases, control benefits may easily be underestimated.



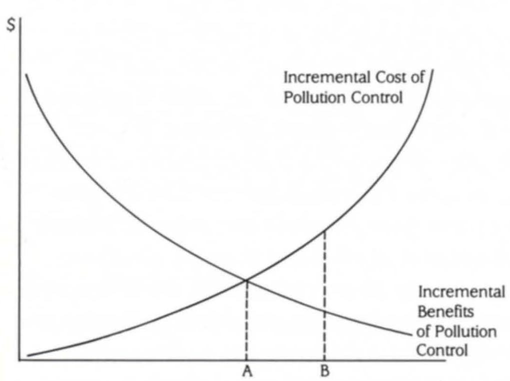


Figure 1. Level of pollution reduction.

Coase (1960) cited legal cases in which it was established that a person may

> make use of his own property or conduct his own affairs at the expense of some harm to his neighbors. He may operate a factory whose noise and smoke cause some discomfort to others, so long as he keeps within reasonable bounds.... The world must have factories, smelters, oil refineries, noisy machinery, and blasting, even at the expense of some inconvenience to those in the vicinity. They may be required to accept some discomfort for the general good.

Coase also cited judges who stated that:

> I know no general rule of common law which says, that building so as to stop another's prospect is a nuisance. Was that the case, there could be no great towns; and I must grant injunctions to all new buildings in this town.
>
> Without smoke, Pittsburgh would have remained a very pretty village.

It is commonly believed that efforts to improve environmental quality usually inhibit community and environmental development, at least in the vicinity of regulated activities. Environmental quality is certainly important, but so are jobs; the optimum environment includes both economic opportunity and good environmental quality. There are, however, economic benefits associated with regulation. Uncertainty can be a deterrent to entrepreneurship, and regulations that remove uncertainties can be conducive to the development of industry, services, and amenities. Clear rules make it possible for businesses to assess costs, and could encourage them to locate in the area. Corporate executives also prefer a favorable location and image associated with an attractive area. While there is little disagreement about the benefits associated with environmental quality, there is considerable disagreement as to how to achieve this goal.

Addressing the Problem

The federal approach to environmental problems has principally relied on uniform controls and standards governing discharge of pollutants or the quality of the environment; taxes and subsidies linked to performance or technological solutions; and market incentives, including discharge fees and marketable discharge permits. The following are examples of proposed and actual methods used to attain a socially optimal level of control of externalities (Davis and Kamien 1969).

Prohibition

Prohibition of the activities responsible for pollution or other undesirable outcomes usually entails significant economic losses. We choose not to ban automobiles, stop steel production or prohibit sewage disposal to eliminate all pollution. However, we do prohibit the use of selected chemicals such as DDT and other long-lived and harmful substances. Some might seek to achieve perfectly clean water or air but the optimum solution requires only that the "right amounts" of these externalities be present. For instance, lakes and streams have some capability to cleanse themselves and prohibiting all effluents would waste this natural capability. However, where the costs (or benefits) associated with an environmental problem are unknown, prohibition may reduce uncertainty and simplify decision-making.

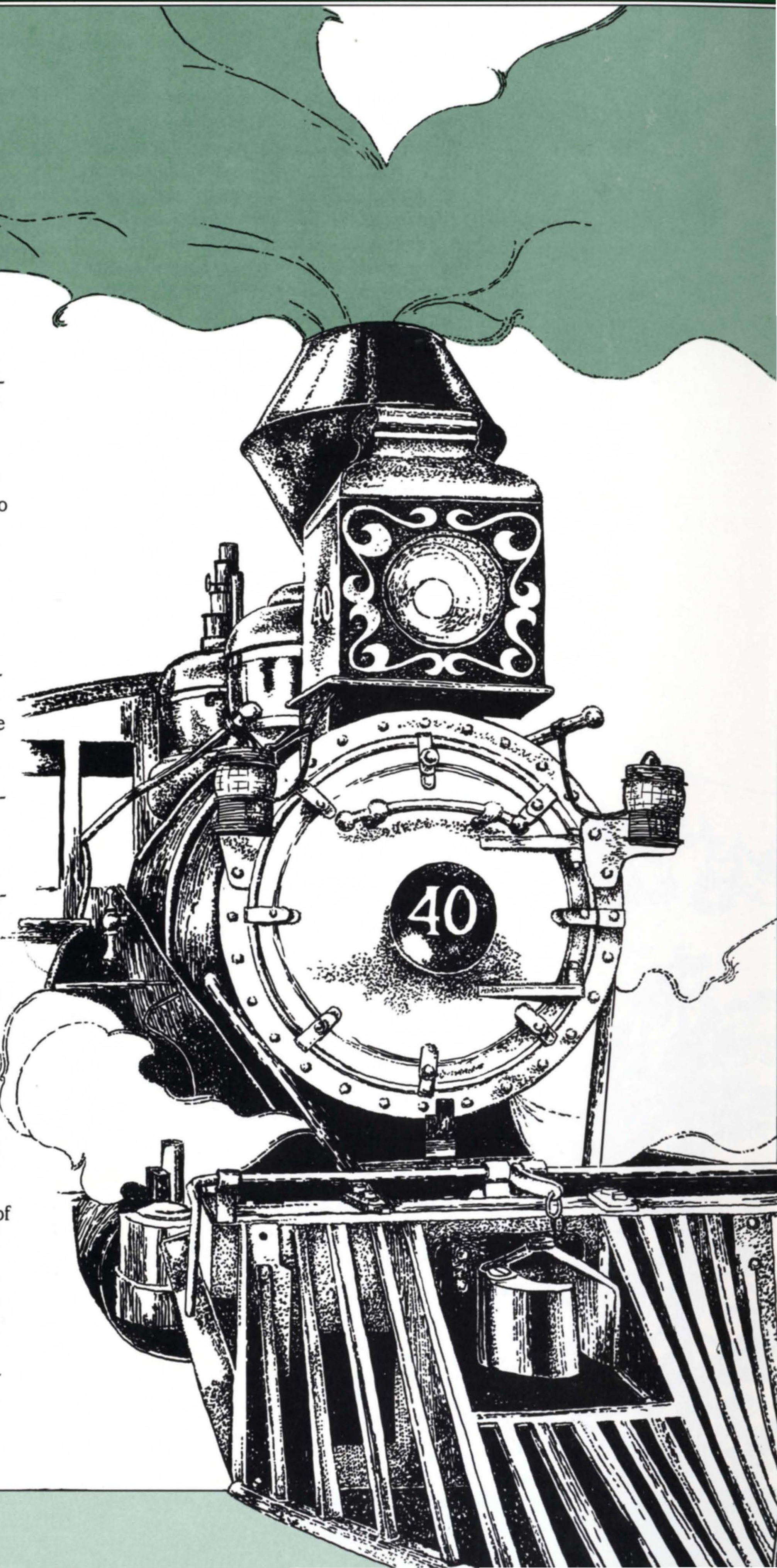
Directives

Directives involve the determination of acceptable level for an externality (e.g., the percentage of organic matter, phosphorus in sewage effluent or the amount of smog in a city). This procedure might be consistent with the social optimum but most directives are established without an accurate benefit-cost analysis. It is extremely difficult to determine the benefits associated with pollution abatement, particularly when several sources are involved. The administrative costs associated with directives are frequently prohibitively high.

Voluntary Action

Voluntary action to correct problems may be motivated by payments, mergers, a sense of social responsibility and public opinion or moral suasion. Voluntary actions are often successful; for example, as when a neighbor voluntarily turns down his stereo. A community might pay a steel producer to reduce emissions; if the producer refused the offer, then the producer feels the ability to release effluents is worth more than the payment. Action may be precipitated by the threat of a reduction in business or adverse publicity. In some cases, a downstream or downwind recipient of pollutants may benefit by merging with the polluting firm.

In an environment where perfect bargaining is possible, socially optimal solutions can be attained. However, bargaining is usually not perfect and when many people and businesses are involved, bargaining, payments or other kinds of voluntary action probably will fail, either because some beneficiaries of an agreement will not pay their fair share, there is a lack of information, those affected take no action or costs and benefits cannot be determined.



Taxes and Subsidies

Taxes and subsidies imposed by the public sector can encourage socially desirable activities and discourage those that are undesirable. For example, a tax equal to the damage could be imposed on a firm that discharges harmful wastes (e.g., fines recently imposed on some firms in Utah). The firm would probably continue to discharge if it is cheaper to pay the tax than to stop polluting, or it could stop part or all of the discharge if the cost of reducing pollution is less than the tax. In principle, it should be possible to reach an optimal solution if adequate information is available. However, we have no assurances that entities harmed by the discharge would in fact be compensated by the public sector. In practice, government seldom knows how much discharge maximizes the public good. Enormous amounts of information may be required when more firms and households are involved. Obtaining such information, even at very high cost, may be justified if the potential losses are also very high. Decision makers must compare the incremental cost of obtaining additional information with the losses to society that result from these externalities.

Market Mechanisms

The two basic market-based approaches utilized to protect the environment are pollution taxes (emission fees) and marketable discharge permit systems. Emission fees and market permits might be about equally effective in promoting economic efficiency, but they have very different social consequences (Nelson 1987). Emission fees in effect mean the public owns the nation's air and water domains and private firms would obtain temporary leases for emission from the government. In contrast, the market-permit approach establishes a private ownership system; pollution rights to the nation's air and water domains would be divided up and assigned to individual owners. Nelson also suggested that government administrators could theoretically raise or lower emission fees to change pollution levels. This contrasts with the permit approach because the government would have to purchase previously issued pollution rights to reduce pollution.

Regulation

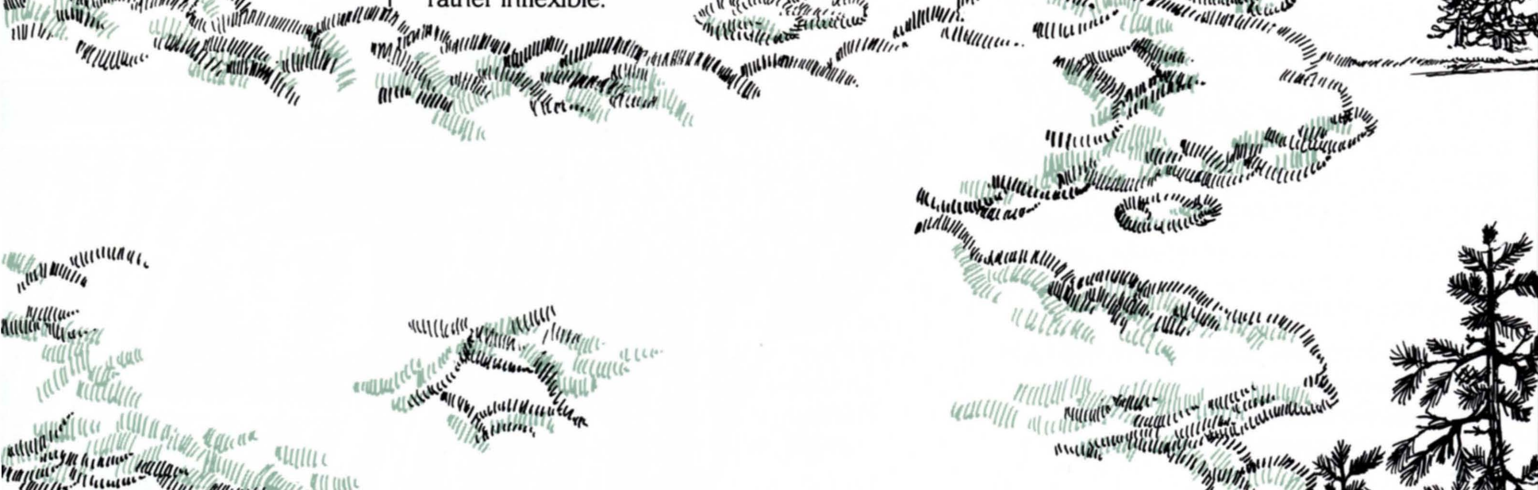
Regulation has been used to limit air pollution, e.g., lead-free gasoline and requiring pollution-control devices on all new cars. There are limitations associated with this method. Enforcement may be difficult, effectiveness may be difficult to determine, and regulation entails direct administrative costs. For example, catalytic converters on cars must be maintained and tested periodically. They may have relatively little social value when installed on cars operated in rural areas where air pollution is not considered a problem. Thus, the expenses associated with the purchase and maintenance of catalytic converters and reduced fuel economy may have few beneficial effects in some areas while the benefits may be high in other areas. Regulations are often not consistent with a socially optimal solution because they tend to be rather inflexible.

Payments

Payments are obvious ways to overcome technological externalities. If a lake is polluted because of inadequate sewage treatment from one or more of several cities bordering the lake, other users of the lake incur part of the cost of inadequate sewage treatment. Because each city does not bear the full cost associated with pollution, none has an incentive to solve the problem. One possible solution to the problem involves subsidies for the capital costs associated with improvement to sewage systems. Federal subsidies to construct or improve local sewer systems are widely used in the United States. However, subsidies are only effective if lack of capital is the only impediment to improvement and it is possible to impose pollution-abating activity on those responsible. Furthermore, costs for some participants may not always be proportional with the benefits received. Changing local regulations, such as zoning, and encouraging private agreements may reduce uncertainty and encourage innovative solutions.

Direct Action

Simple and direct action can ameliorate the effects of an externality. For example, overfishing can endanger the future fish population. An individual fisherman has no incentive to catch fewer fish since he assumes that others will catch any fish that remain. The government can stock the stream or lake to maintain the fish populations. Such direct action shifts the problem associated with the externality to all taxpayers. Thus, direct action can be costly to nonbeneficiaries and therefore has limited application.



Summary

Approaches used to correct market failures range from the laissez-faire methods to prohibition of certain offensive activities. Despite these differences, all approaches would benefit from more reliable information concerning the source(s), dispersion/transport, timing, and consequence(s) of specific pollutants.

Of the many policies available to deal with technological externalities, none are perfect, nor is any best for every situation. Policies must be tailored for particular situations. However, governments have a proclivity for legal solutions and tend to rely on laws and regulations. These regulations may not provide for a socially optimal solution.

Benefit-cost analyses are appropriate to employ in environmental regulation. There are benefits associated with every action (including inaction). The optimal solution is that which provides the greatest net benefits.

Environmental regulations may impede economic development if they are not soundly prepared. An understanding of the costs, benefits and the principles involved in environmental regulation should promote both a clean environment and appropriate community and industrial growth.

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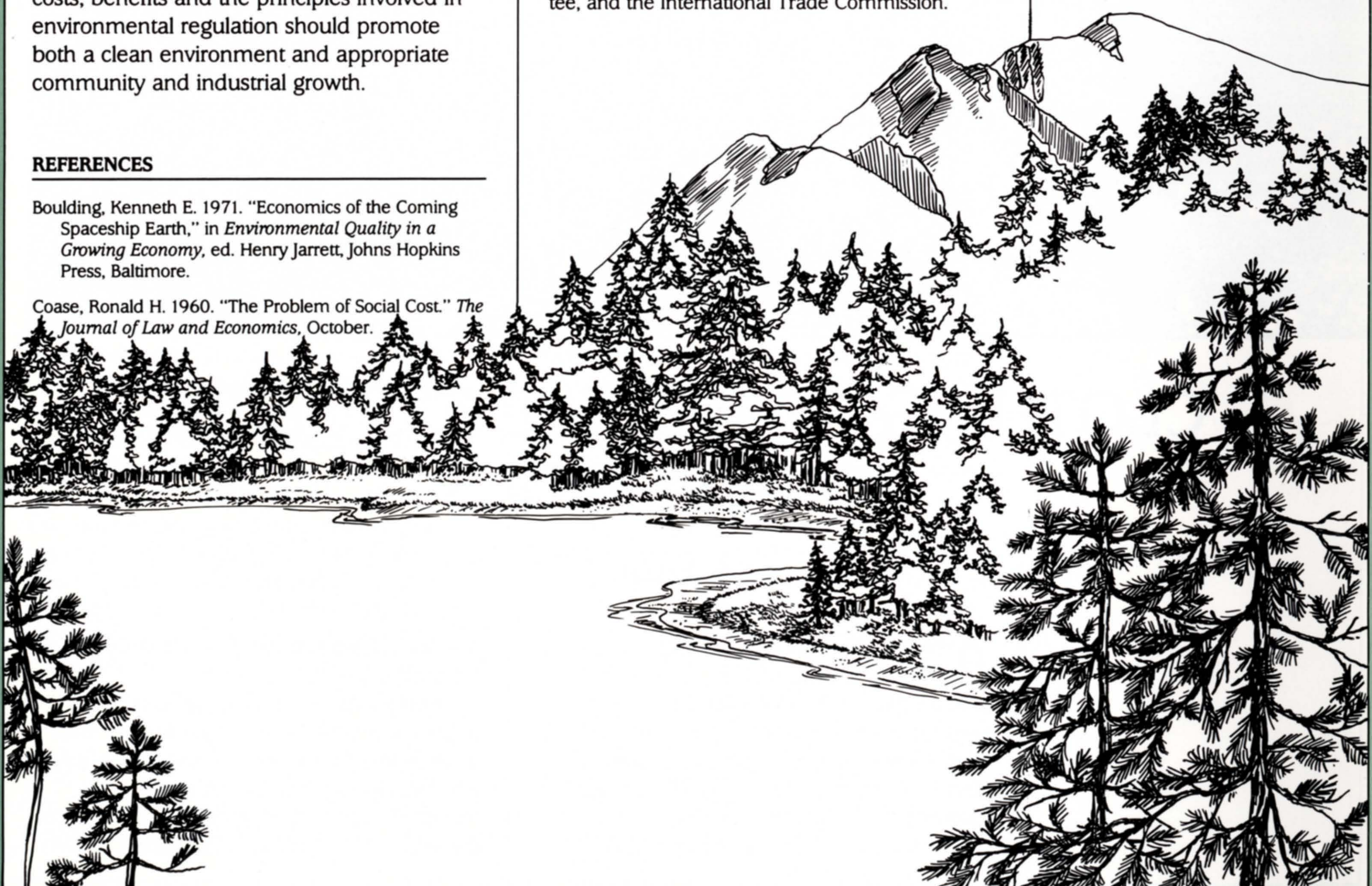

CLOTHING TO REDUCE EXPOSURE TO PESTICIDES

V. B. KEEBLE

American farmers use about 2.3 billion pounds of pesticides annually in the production of fruits and vegetables. Many pesticides are associated with hazards ranging from acute toxicity to cancer, birth defects, genetic mutations and sterility (Nelson and Fleeker 1988). Each year more evidence shows that chronic exposure to pesticides may be related to serious health problems (Mcdonald 1987).

Dermal exposure poses a greater health hazard to most agricultural applicators than other types of exposure (inhalation, oral). An effective clothing barrier can significantly reduce the amount of pesticide that contacts the skin during mixing and application. Even though there is clear evidence of the value of protective clothing and equipment such as masks, goggles, gloves, boots and respirators, relatively few agricultural workers use protective clothing due to the inconvenience associated with the clothing and equipment. Rainsuit type clothing is heavy, hot and uncomfortable during most of the year. New types of clothing such as Tyvek are lighter but are not very comfortable in hot weather. Those who are prone to heat stress must be very careful when wearing protective clothing that is impervious to liquids.

Relatively little research has concerned suitable designs and fabrications for protective clothing. Research is also required to ascertain the protection offered by clothing during the handling, mixing and application of pesticides. Protective clothing must balance the need for protection with thermal comfort. The optimum protective gear would provide an impermeable barrier to hazardous chemicals but still allow wearers to remain comfortable while working. Few clothing materials are both protective and comfortable.

Garments Produced in College of Family Life

In 1984, students enrolled in design classes in the USU Department of Home Economics and Consumer Education designed and produced a protective suit and separate hood and manufactured garments from one fabrication. The same design was used to construct garments from two other protective fabrics by manufacturers of protective clothing. The protective suits were made of Gore-Tex, a multilayer fabric which is protective and likely to be comfortable because of its breathability; Saranex-laminated Tyvek, a fabric whose supplementary coating increases protection but decreases comfort; and an experimental composite fabric, which breathes and had also reduced pesticide penetration in laboratory studies. Utah fruit growers tested the thermal comfort and protective ability of the clothing when they applied pesticides during July and August, 1986. We also tested the protection offered by the work clothing that growers normally wore.

The Field Study

Ten Utah fruit growers participated in the study; five were orchard owners, two were managers and three were full-time employees. All sprayed apples, while four also sprayed peaches and two sprayed pears. The test pesticide was Guthion (azinphos-methyl). One grower applied the pesticide from a tractor with a hand spray gun while the others used air blast sprayers. All 10 growers wore the three protective garments. Results were compared to self-selected work clothing that growers wore when applying pesticides. Five growers selected conventional work clothing consisting of long sleeved shirt and trousers. Four growers selected lightweight Tyvek spray suits that lacked the Saranex coating and hoods. One grower wore a garment similar to a rubberized rain suit (pants and hooded jacket), which was the type of protective clothing available before Tyvek was introduced. It was much heavier than clothing made from Tyvek. The data in this article do not include the single rubberized spray suit.

Penetration of the pesticide was measured by pads taped inside and outside of the garments. Inside pads were completely covered so only pesticide that penetrated the fabric contacted the pad. Pad placement on the protective suits and the workers' clothing is shown in Figure 1. Pads were attached before workers entered the orchards. Exposure pads were removed and analyzed for Guthion at the end of the test period.

Table 1 shows the number of pads, kilograms of active ingredient applied by the worker, the average amount on pads and the percentage of outside and inside pads that contained measurable levels of Guthion. An average of 3 kilograms of active ingredient was applied by workers wearing each type of protective clothing. Workers usually sprayed the same type of crop during each test period. However, when workers wore regular clothing (long sleeved shirts and trousers), they tended to apply less pesticide than when they wore protective clothing made of Tyvek.

Only three of the 260 pads showed no detectable levels of Guthion. Average levels on the outside pads ranged from 2.6 $\mu g/cm^2$ for regular work clothing to 9.2 $\mu g/cm^2$ for the composite structure. Even though the outside pads on the conventional work clothing contained the least Guthion, the inside pads on this clothing had the highest levels of Guthion, which seemed to indicate that growers were more cautious when they mixed and applied pesticide because they thought this clothing would provide less protection.

There were measurable levels of Guthion on 58 percent of the inside pads on regular work clothing, the highest percentage of any of the garments tested. Thirty percent of the inside pads on Tyvek garments that growers wore as work clothing contained measurable levels of Guthion, while 13 to 21 percent of the inside pads on the three protective suits contained measurable levels of pesticide. Based on the average amount of Guthion on the inside pads, pads in regular work clothing contained 2 to 4 or more times as much Guthion as pads in the protective clothing. Although the levels are relatively low, this was the average exposure per square centimeter over an average exposure period of 2 hours. Many growers worked for much longer periods, perhaps more than 8 hours daily.

Although protective clothing usually reduces exposure to pesticides, wearing protective clothing can occasionally be more hazardous than conventional work clothing. Protective clothing that is impervious to liquids repels liquid pesticides but also prevents the dissipation of heat and moisture from the skin, which may increase the risk of heat stress during warm weather. Tyvek effectively repels liquid pesticides and clothing made of this material may be very hot and uncomfortable in hot weather. Gore-Tex fabric breathes but pesticides can adhere to the fabric. Laundering studies conducted at other institutions have shown that it is very difficult to remove pesticides from Gore-Tex. Gore-Tex was the only non-disposable material tested in this study. It must be effectively cleaned before re-use. The other fabric tested appears to provide an effective barrier to pesticides and is relatively comfortable. Although effective fabrics that are comfortable at temperatures above 80°F are not yet available, the composite structure warrants further study. Thermal comfort of protective clothing was evaluated, but is not reported in this article.

Exposure for Growers

Work habits also affected exposure. Table 2 shows the average levels of Guthion on the outside pads for the 10 workers. They ranged from less than 1 $\mu g/cm^2$ to almost 18 $\mu g/cm^2$. Ninety-nine percent of the outside pads contained measurable levels of Guthion. One worker weighed Guthion in a container on a small scale, which was about the same height as the shin pads on his rubberized spray suit. Those pads contained 100 times more Guthion than the levels reported in this study. If the worker had not been protected by a spray suit, his skin would have been exposed to high levels of the pesticide when it was poured into the container.

TABLE 2. Average contamination on the four garments tested by growers.

Grower	Number of pads (n = 260)	Average contamination ($\mu g/cm^2$)
1	25	2.521
2	19	.963
3	26	11.535
4	27	2.713
5	34	2.111
6	27	5.921
7	25	.978
8	27	17.820
9	26	2.362
10	24	4.225

TABLE 1. Outside and inside contamination for each garment.

			Outside contamination			Inside contamination		
	Growers	Active ingredient applied, Kg	Number of pads	Percent pads with measurable Guthion	Average ($\mu g/cm^2$)	Number of pads	Percent with measurable Guthion	Average ($\mu g/cm^2$)
Work clothing								
Regular	5	1.7	31	100.0	2.60	29	58.0	0.004
Tyvek	4	4.1	22	100.0	7.05	22	30.0	0.001
Gore-Tex	10	2.8	61	98.5	3.85	61	13.0	0.000
Saranex								
Laminated Tyvek	10	2.7	67	98.5	3.60	66	21.0	0.002
Composite structure	10	2.7	67	98.5	9.20	65	21.0	0.001

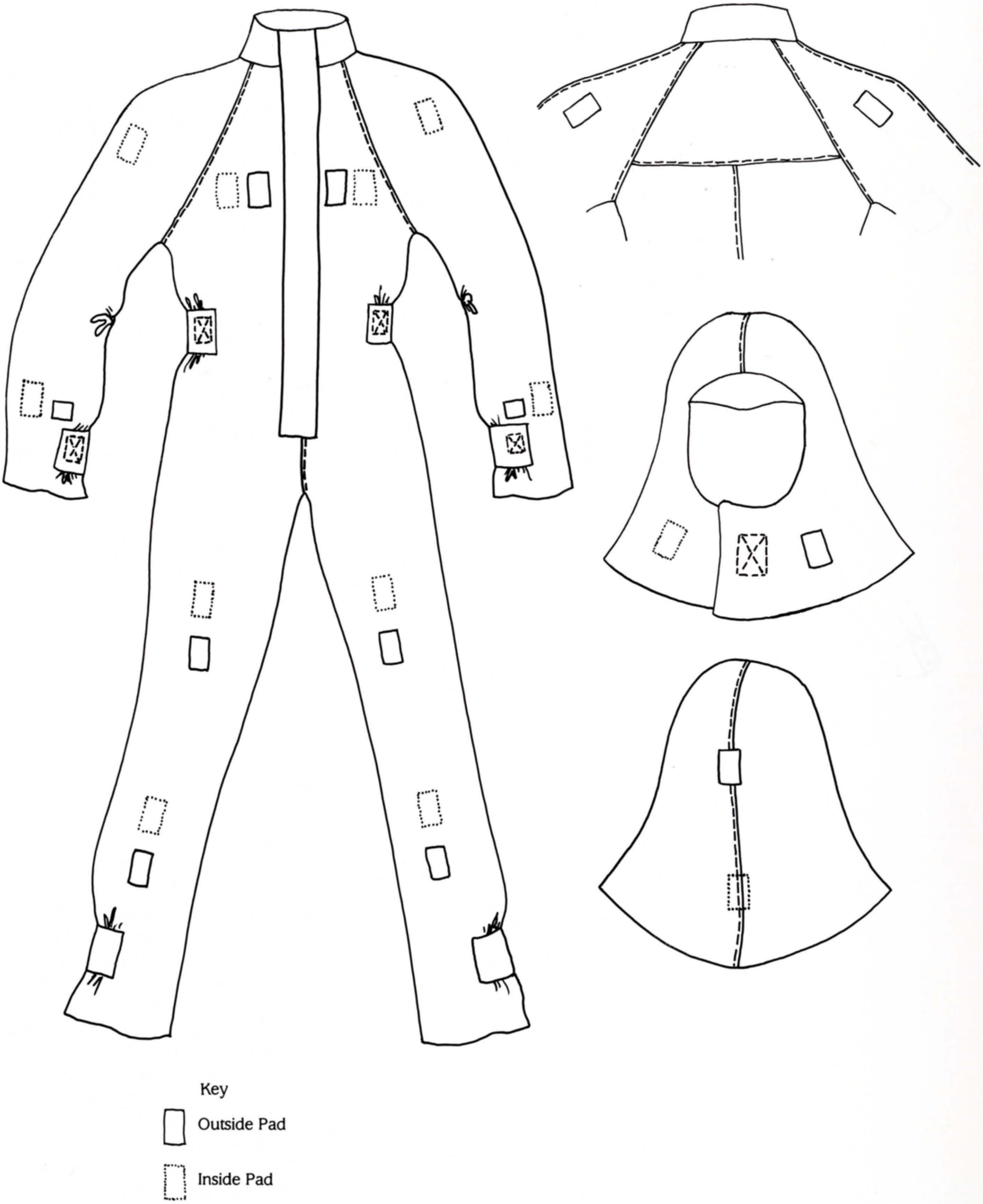

Figure 1. Placement of outside and inside pads on protective suit and conventional work clothing.

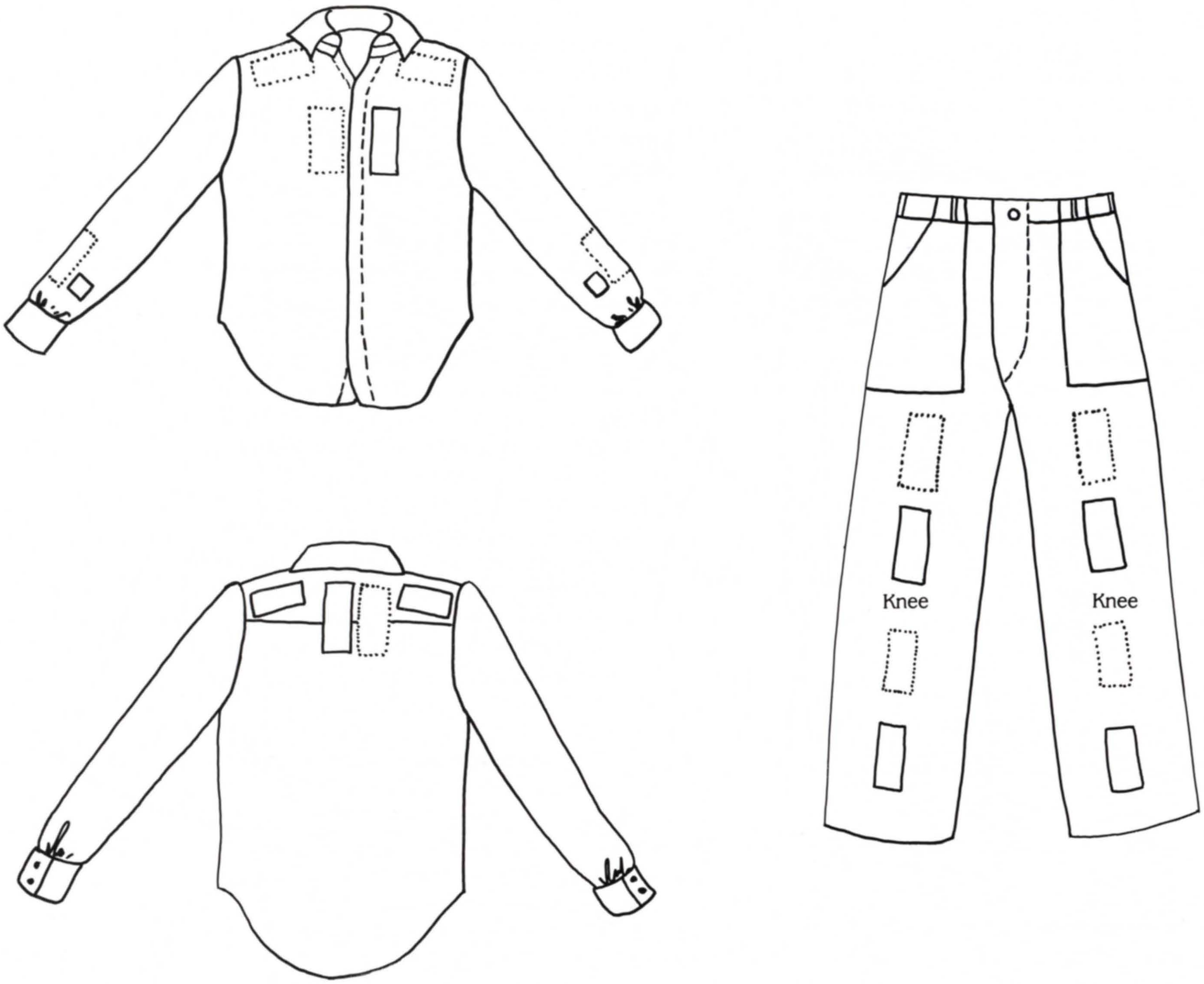

Figure 2. Patch placement on work clothing.

Pattern of Exposure

The pattern of exposure was determined according to level of exposure and location. Because pads from both sides of the body were analyzed together, it was not possible to determine whether exposure differed between the right and left sides. The thigh area had the highest exposure, followed by the forearms and shins. Areas with lowest exposures included the hood neck, the waist, the chest, the shoulders and the back of the neck (see Figure 1).

Conclusions and Recommendations

Ninety-nine percent of the outside pads on all clothing were contaminated with Guthion. Amounts ranged from 2.6 $\mu g/cm^2$ for conventional work clothing to 9.2 $\mu g/cm^2$ for the composite fabric. Almost 60 percent of the inside pads on conventional work clothing were contaminated, and the average level of contamination of inside pads was the highest of the clothing tested. All of the types of spray suits tested offered some protection.

Average levels on outside pads varied from less than 1 $\mu g/cm^2$ to 18 $\mu g/cm^2$. Some areas of the body were exposed to higher levels of pesticide. Contamination was highest on the thighs. Forearms and shins were also exposed to relatively high levels of Guthion.

Careful work habits can reduce pesticide exposure. Protective clothing worn during cooler weather can effectively reduce exposure, but conventional work clothing may be

TABLE 3. Outside contamination by location for all test garments.

Outside	n	Mean contamination ($\mu g/cm^2$)
Hood neck	25	1.39
Hood seam	24	3.03
Shoulders	39	2.00
V of chest	7	1.34
Chest	33	2.50
Forearms	39	5.45
Thighs	39	16.98
Shins	38	4.06
Neck back	6	1.95

more comfortable during hot weather. If protective clothing can not be worn, applicators can significantly reduce exposure to pesticides by showering immediately after applying pesticide and by carefully laundering contaminated clothing. The following recommendations are based on research conducted in other states.

- Clean clothing after each use because residues build up in fabrics from repeated application of pesticides.
- Launder contaminated clothing immediately after use.
- It is difficult or impossible to remove undiluted agricultural chemicals that have been spilled on clothing. This clothing should be discarded.
- Pre-rinsing contaminated clothing at least twice before laundering removes pesticides more effectively than a single laundering.
- Commercially available pre-wash products and typical laundering procedures effectively reduce contamination.
- Hot water and warm water washes are equally effective, but washing in cold water wash is not.
- Heavy duty liquid detergents most effectively removed some emulsifiable concentrates.

Surfactants in heavy duty liquid detergents emulsify and dislodge oily soils. Granular detergents removed wettable powders, flowable, water soluble concentrate, and encapsulated formulations. Common salt was effective in removing paraquat residue but was not useful for general use.

Pesticides from contaminated clothing are transferred to other items laundered in the same wash load. Never wash pesticide-contaminated clothing with other clothing.

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ABOUT THE AUTHOR

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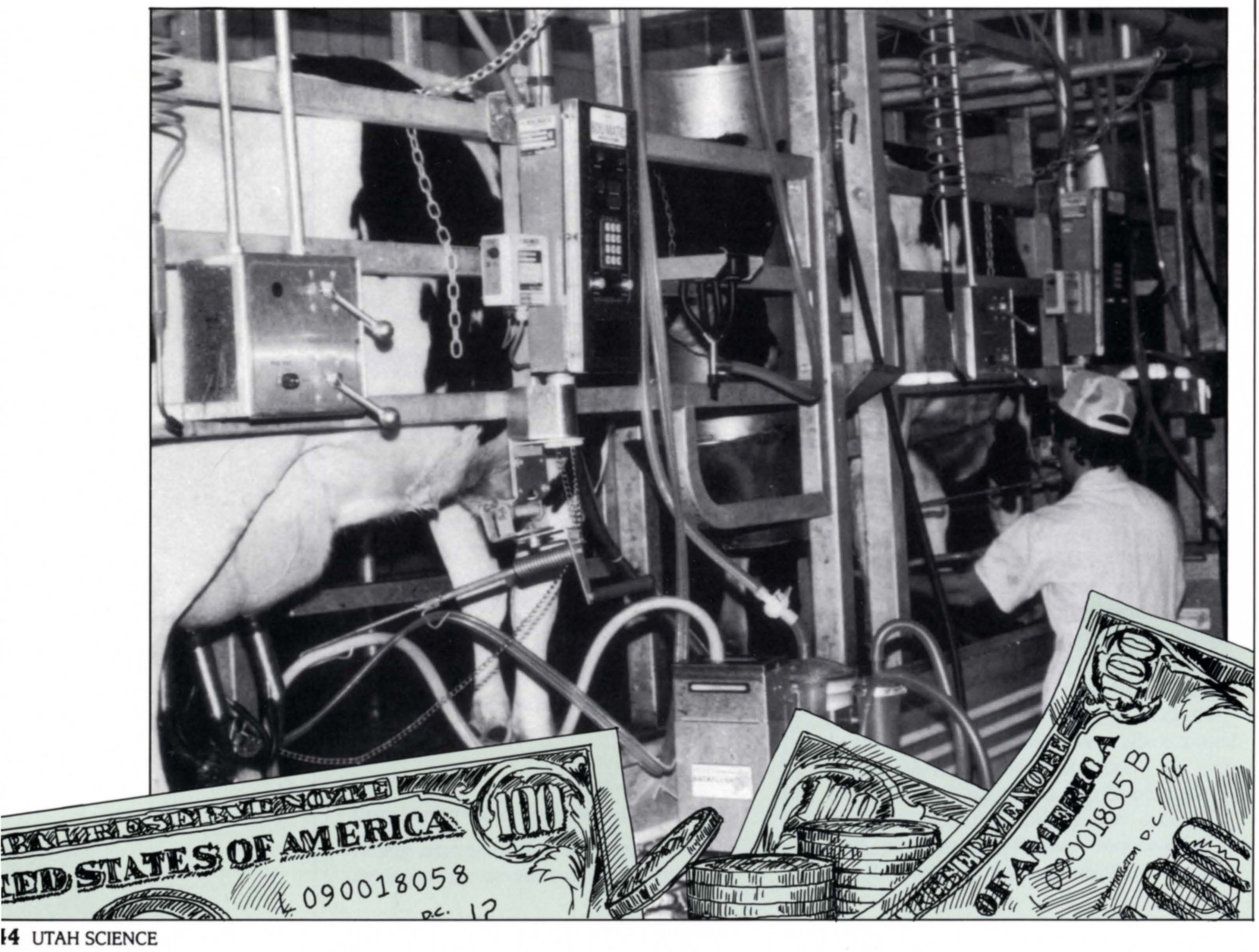
The farm financial crisis has affected all segments of Utah agriculture. Low farm prices, reduced government price support levels, high real interest, and declining asset values all served to make the early and mid 1980s tough times for farmers in Utah and elsewhere.

The dairy industry in Utah also suffered. The dairy industry is highly capital intensive. Cow numbers and milk production in Utah expanded rapidly between 1979 and 1983 (1987 Utah Agricultural Statistics), a period characterized by high interest and inflation rates. In addition, many dairy investments during those 5 years were made in anticipation that farm assets, especially land and buildings, would continue to appreciate rapidly. Instead, they depreciated in value. Moreover, dairy price support levels decreased in the last 3 years. All these factors made the dairy industry in Utah vulnerable to financial difficulties.

A SURVEY OF THE FINANCIAL CONDITION OF UTAH DAIRY FARMS IN 1985

D. BAILEY, G. O. JENSON and N. ACKERMAN



In 1985, 25.1 percent of all agricultural sales in Utah were related to dairy products, second only to cattle as a source of farm income. The diary industry is the leading agricultural enterprise in some counties. In 1982, 54.3 percent of all agricultural sales in Cache County were generated by dairy products (U.S. Department of Commerce). Comparable figures for selected other counties were 48.9 percent for Wasatch County, 44.3 percent for Weber County, 30.3 percent for Box Elder County, and 27.2 percent for Utah County.

In cooperation with the Utah Cooperative Extension Service, the office of the Vice President for Research at USU, and the Utah Agricultural Experiment Station, a study was conducted to learn whether certain family and personal factors were related to the ability of farm families to cope effectively with the economic crisis.

This study focused on the financial condition, levels of stress and stress management techniques, and overall life satisfaction on dairy farms in Utah. It also identified aspects of financial management and family well being. A random sample of dairy farm families in Cache, Box Elder, Weber, Utah, and Wasatch counties were surveyed. A total of 116 farm couples were interviewed. Ninety-one of those interviews provided enough financial information to be included in this study. This report focuses on the financial status of Utah dairy farm families. Subsequent articles will focus on stress management and life satisfaction.

The basic measures of financial health for a firm are solvency, liquidity and profitability. Solvency is defined as the ability of a firm to meet all financial obligations. One of the most common measures of solvency is the debt-to-asset ratio, which is obtained by dividing all outstanding debt obligations by total assets. Liquidity is the ability of the firm to meet the current year's obligations without disrupting the normal operation of the firm or its current capital structure. This measure concerns the cash flow position of the firm. There are many measures of profitability. We used the percentage return on assets.

Several categories of farms were analyzed. The first involved size: small, gross annual sales for 1985 of less than $100,000; medium, sales between $100,000 to $250,000; and large, more than $250,000 in sales.

Another type of analysis concerned the debt position of the farmers. There were two groups—those with little or no debt (debt-to-asset ratios of 0.2 or less) and those with significant debt (debt-to-asset ratio greater than 0.2).

We also examined whether farms participated in USDA's Dairy Termination Program (DTP), known as the "whole-herd buy out" program, to determine whether the financial characteristics of farms that participated in the DTP differed from those that remained in dairying. Many analysts believed that the DTP provided an excellent opportunity for farmers with financial problems to leave the industry.

After determining the financial health, firm management and operator characteristics, a regression analysis was conducted to determine whether profitability of the farms was related to other farm characteristics, including financial, structural and production characteristics.

Production

Average milk production (rolling herd average) on the farms surveyed was 16,432 lb. (Table 1) compared to the state average of 13,675 lb. in 1985. Average milk production in large herds was 23 percent greater than in small herds. Operators of larger farms were also more likely to feed balanced rations designed to achieve production goals and/or reduce feed costs.

Solvency

Based on the overall ability to meet all their debts (solvency), dairy farmers appeared to be in good financial condition. An average debt-to-asset ratio of 0.36 (Table 1) for all farms was below the 0.4 threshold that USDA economists associate with financial difficulties.

Large farms were more heavily indebted than small farms, probably because operators of large farms recently made capital investments in equipment (cows, barns, machinery, etc.) and/or in better technology (computerized systems, improved genetics, etc.). Participants in the DTP were substantially above the 0.4 threshold. However, even this group was well below the 0.7 debt-to-asset ratio indicative of severe financial stress.

Many of the dairy farms with significant amounts of debt (those with medium to large debt in Table 1) may be experiencing severe financial difficulties. This group, which

TABLE 1. Average economic and financial characteristics of dairy farms surveyed.

	Size of farm			Debt load		Participation in termination program		
	Small	Medium	Large	Small	Medium to large	Yes	No	All farms
Number	19	45	27	51	40	15	76	91
Operator's age	51	52	50	54	47	49	52	51
Operator's education (years)	13.8	13.2	13.4	13.5	13.2	13.7	13.3	13.4
Family off-farm income	$10,558	$5,671	$4,345	$7,637	$4,591	$5,641	$6,428	$6,298
Debt-to-asset ratio	0.28	0.30	0.41	0.08	0.59	0.48	0.31	0.36
Total assets	$231,886	$441,658	$742,629	$464,869	$508,789	$489,096	$484,551	$524,775
Number of cows owned	40	84	187	85	131	102	106	105
Acres owned	72	156	335	168	220	123	205	192
Acres rented or leased	38	112	185	95	148	169	109	118
Cash flow[a]	.76	.71	.70	.67	.76	.74	.71	.71
Net cash farm income[b]	$18,649	$47,654	$114,192	$55,927	$68,261	$51,985	$63,715	$61,516
Net farm income[c]	$7,108	$26,965	$69,853	$33,051	$38,752	$29,272	$37,102	$35,634
Percent return on farm assets[d]	0.8%	7.7%	12.7%	7.2%	8.8%	6.3%	8.4%	8.0%
Rolling herd avg. (lb.)[e]	14,443	16,490	17,831	16,055	16,989	16,446	16,530	16,432

[a]Cash flow = (estimated 1985 cash expenses − principal payments)/estimated 1985 farm income.
[b]Net cash farm income = farm income − cash expenses (excluding principal payments).
[c]Net farm income = net cash farm income − estimated average depreciation.
[d]Percentage return on farm assets = (net farm income + interest expenses − value of unpaid family labor)/total assets.
[e]Average milk production per cow.

included only farmers with debts amounting to 20 percent or more of assets, accounted for 44 percent of the farmers surveyed. The average debt-to-asset ratios of these farmers was 0.59—well above the average for the entire population (Table 1). Most debt was borne by fewer than half of the farmers surveyed. These findings are consistent with the results of other studies that indicate a significant portion of dairy farmers in Utah are experiencing mild to severe financial stress. However, the majority of the farmers surveyed (56 percent) had little or no debt.

Cash Flow

Farmers and agricultural lenders are concerned about the cash flow capability of farm operations. We estimated the ability of the farmers to generate enough income to meet the current year's expenses (cash flow in Table 1). The estimate was obtained by adding estimated gross income from milk receipts and the sale of livestock and crops, and then dividing this figure by 1985 cash expenses (excluding principal payments). Some lenders believe that a ratio of 0.7 or less represents an acceptable cash flow position. The remaining 30 percent of income not used for current expenses is considered necessary for family living expenses, principal payments and capital replacement.

Cash flow appears to be a larger problem than debt load for the farmers surveyed, especially for small farmers, most of whom augment their farm incomes with a significant amount of off-farm income (Table 1). Other farmers likely to experience cash flow difficulties were some of those participating in the DTP and many of those carrying significant debt. While there was a correlation between high debt and cash flow difficulties, 59 percent of those with cash flow problems had a small debt load (a debt-to-asset ratio of less than 0.4). This suggests that cash flow problems were not simply associated with large debt loads but were a more general problem. Production efficiency, management and economies of size probably affect cash flow. Consequently, cash flow problems may reflect both management decisions and debt load.

Profitability

In this study, the percentage return on assets was used to measure profitability. The percentage return on assets is defined as the sum of net farm income and interest payments minus the value of unpaid family labor; this figure is then divided by the total value of farm assets. The estimated value of unpaid labor was $10,000 for small farms, $15,000 for medium-sized farms and $20,000 for large farms.

In general, small dairy farms were not very profitable and had a return on assets of only 0.8 percent (Table 1). Larger farms appeared to be the most profitable, which was somewhat surprising because they tended to have a larger percentage of debt than the other categories of farms. However, production per cow on large farms was the highest of any category, an indication of better management.

The farming operations of participants in the dairy termination program were less profitable than all the other groups except small farms, which indicated that there were cash flow and solvency problems on these farms.

Regression Analysis

Profit is defined as total revenue minus total costs. Total revenue is the product of output (production) and price. Profit is closely related to net farm income and equals net farm income plus interest expenses (a return on investment) minus the value of unpaid family labor.

Other factors besides output and price may affect profits. For example, education may influence management ability, as can off-farm employment if an operator devotes less time to the dairy operation. Profits also reflect prices for different grades of milk.

An ordinary least squares (OLS) multiple regression of the profit function for the farms surveyed was conducted[1]. As expected, profit levels on these farms were largely related to total output levels (total lb. of milk produced) and total costs[2]. This result was also consistent with the hypothesis that larger farms tend to be more profitable than smaller farms. The results indicated that programs designed to increase output efficiency should also increase profits.

There was a positive, but not statistically significant, relationship between operator's educational level and profitability. Off-farm income was not significantly related to profits. Producers of grade A milk apparently made significantly higher profits than producers of non-grade A milk, an indication of the value of investments required to become a grade A operation.

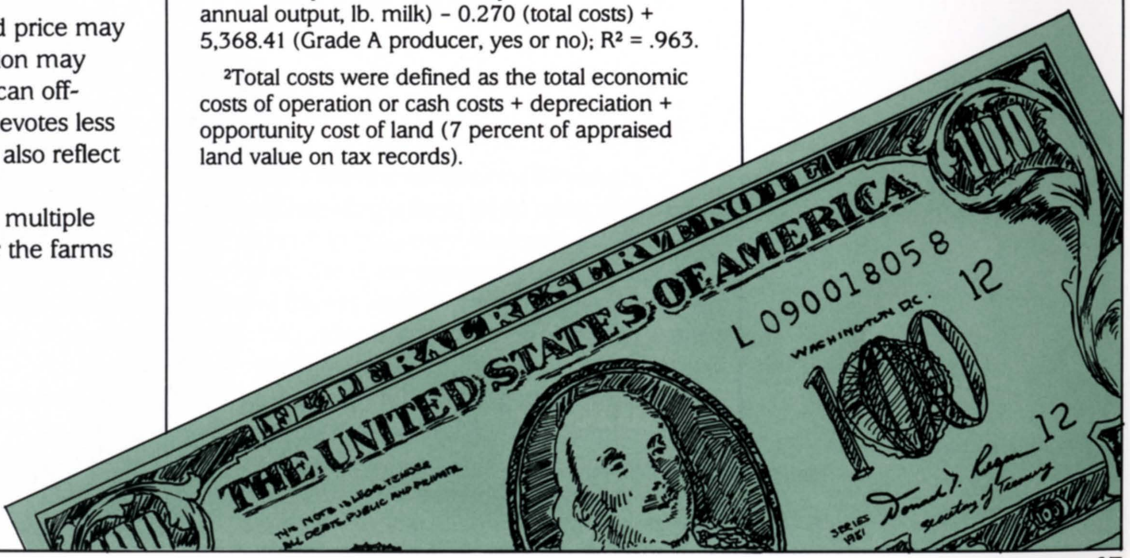
Summary

The dairy industry in Utah at the end of 1985 was a dichotomy: some farms were in sound financial condition and some were experiencing financial difficulties. The dairy termination program helped some financially troubled operators leave the industry. For example, 40 percent of the farmers who participated in the termination program experienced cash flow difficulties prior to terminating operations.

Many producers depend on off-farm income either to subsidize the dairy operation or to supplement income to meet family needs. Large and medium farms generated more net income than small farms. However, in many cases, these larger operations sup-

[1]The multiple regression equation was: Y (profit) = -21,479 - 0.128 (family off-farm income) + 877.306 (operator education, years) + 0.118 (total annual output, lb. milk) - 0.270 (total costs) + 5,368.41 (Grade A producer, yes or no); R^2 = .963.

[2]Total costs were defined as the total economic costs of operation or cash costs + depreciation + opportunity cost of land (7 percent of appraised land value on tax records).



ported two or more families, and these operations may also experience financial difficulties if milk price support levels continue to decline.

Cash flow appeared to be a more pressing concern than debt. However, some farmers carried a disproportionately large share of the debt; over 50 percent of the dairy farmers surveyed had virtually no debt.

Average production levels per cow differed between operations. Large farms had much larger average debt-to-asset ratios but generated much more net income than small farms. Management also appeared to be more intensive on large farms. For instance, 86 percent of the operators of large farms surveyed said they balanced rations compared to only 28 percent of the operators of small farms. If milk price support levels continue to decline, dairy farmers who do not improve their management are likely to experience cash flow problems.

Off-farm employment may provide additional income, but additional income might also be generated if those farmers improved their management of their dairy operations. Some farmers can improve feeding programs, others may have to liquidate some assets and some may have to adjust herd size to maximize returns.

Increasing output efficiency appears to be the best way to increase farm profits. In general terms, this involves either reducing costs while maintaining current production levels or increasing the efficiency of production.

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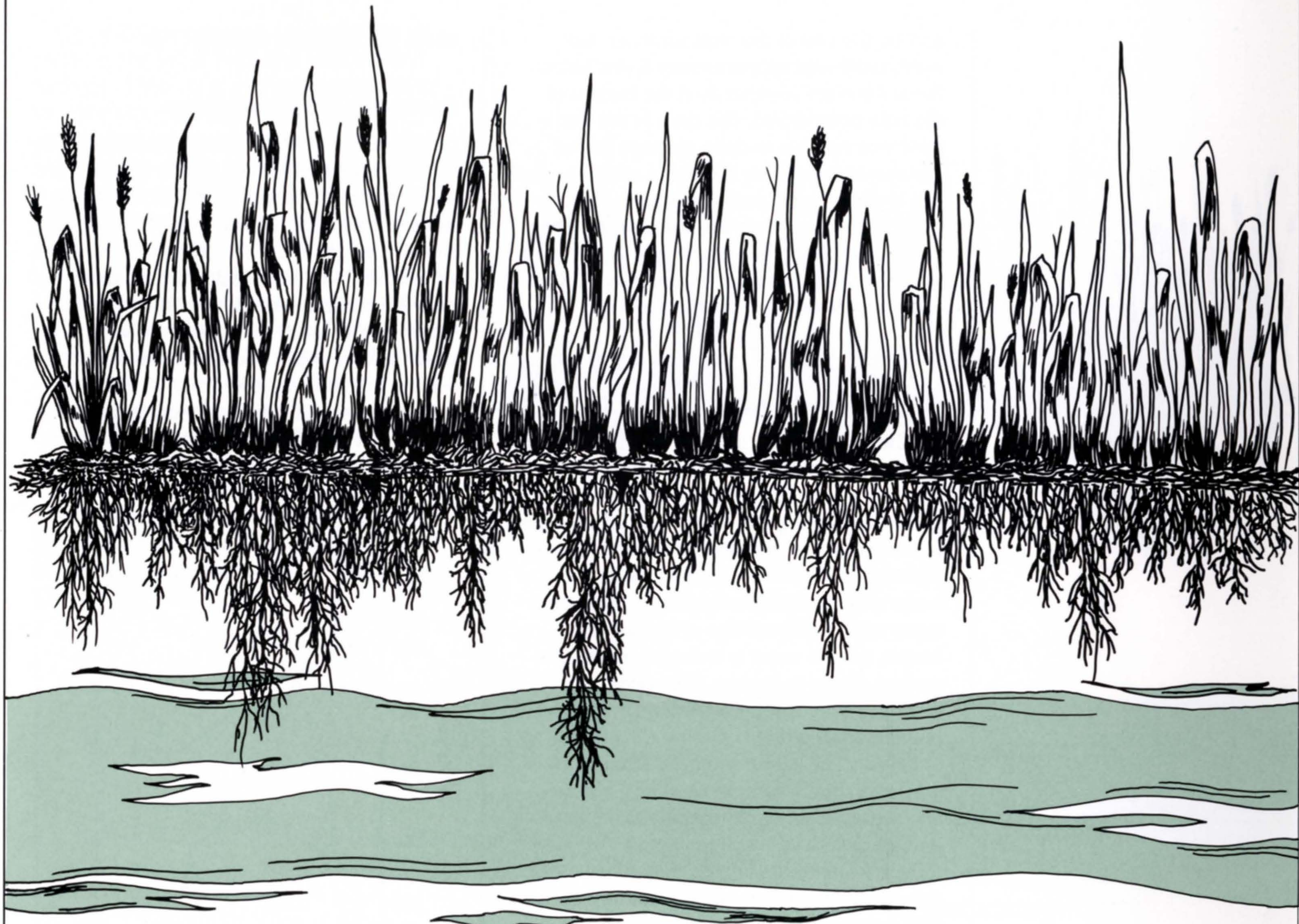


MANAGING WATER TO MINIMIZE DRAINAGE

L. S. WILLARDSON

At the Cache County Reclamation Farm (Drainage Farm), positive water management, coupled with improved grass varieties and fertilizer applications, have resulted in large increases in forage production on once-swampy land. The management techniques also effectively control soil salinity.

When the Drainage Farm was obtained by the University in cooperation with Cache County in 1957, the swampy farm contained mainly unpalatable native grasses and sedges that could tolerate continuous flooding. Researchers dug a large deep open drain in an attempt to "solve the drainage problem." However, the drain remained nearly empty in spite of excess water entering the farm from a large natural spring and runoff irrigation water from nearby lands.

The water from the spring was diverted into the new open drain and some wild artesian wells on the farm were then permanently plugged. The Farm immediately began to dry and by the end of the next summer, the water table was approximately 8 feet below the soil surface (deeper than the bottom of the new open drain). The drop in the water table was not due to deep seepage loss of groundwater because the entire area is underlain by an artesian pressure aquifer, which tends to force water in the soil upward. The water table dropped because plants removed water from the soil after uncontrolled surface water had been eliminated.

Plants Lower the Water Table

For the past 4 years, detailed measurements of the water table show that it generally remains low from the fall until the spring snowmelt. During the winter, no surface water is allowed to run onto the farm and only precipitation and snowmelt would cause the water table to rise. Snowmelt can bring the water table to the surface of the soil, but excess surface water is removed by shallow surface drains or ditches. The water table begins to drop when the weather warms as plants start to grow.

Established grasses are not damaged by a temporary high water table during relatively cool weather. When temperatures increase and grass growth is at a maximum, the water table is low enough to allow necessary aeration of the upper part of the plant root zone. Soil moisture from winter precipitation is usually adequate for good first cutting yields.

Moisture remaining in the soil profile after the first cutting is not adequate for the second crop. Irrigation at this time replenishes the soil moisture in the root zone for the second cutting and may also provide soil moisture for some third growth for pasture. Without irrigation, some forage for pasture would be available after the first cutting.

No water is applied on the Farm after August 1 to enable plants to dry the soil profile and lower the water table. By late fall, the soil should be as dry as possible and the water table should be deep enough to prevent salt from rising to the surface during the spring snowmelt.

The management of water in the soil root zone profile has also controlled salinity. Artesian pressure tends to force water toward the surface, which would ordinarily cause salt to accumulate on the surface. Salt appears to have accumulated on the soil of surrounding farms but not at the Drainage Farm.

Controlling Salt Accumulation

Deep and detailed soil samples indicated why salt had not accumulated on the soil surface and why the crops were not affected by the salt that had accumulated in the soil. Figure 1 shows changes in the salt content of the soil with depth. The lowest salt content occurs near the surface because rain and irrigation water tend to leach salt downward when the water table is deep. The salt content near the surface in 1985 was lower than in 1959 because controlling the water on the farm moved salt deeper into the soil profile where it has little effect on plant growth.

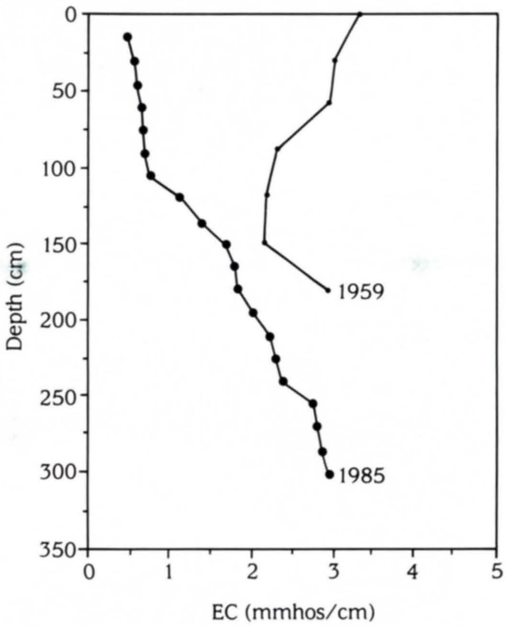


Figure 1. Variation in salt concentration (E. C.) with depth, September 1985 and 1959.

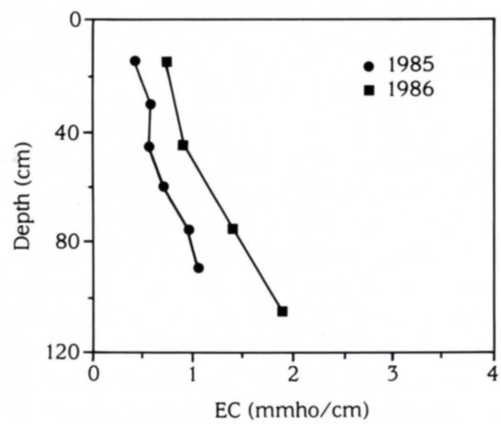


Figure 2. Comparison of electrical conductivity (E. C.), September 1985 and June 1986.

Figure 2 shows the salt content of the soil profile in the fall of 1985 and after the first cutting in 1986. As plants used water, water (and the salt it contains) tended to move upward from the water table into the drier root zone. As shown in Figure 2, the salt in the lower profile moved up about 30 cm (1 foot). This shows why the water table must be as deep as possible before winter so salt can later be leached by winter precipitation or careful irrigation. The salt-free winter precipitation is more effective than irrigation water in leaching salt from the upper profile, but the water table must be deep to allow salt to be washed downward.

Excessive winter precipitation may raise the water table to the soil surface and surface runoff can result. This has little effect on soil salinity since the excess water in the upper layers of the soil, which primarily consists of rain water and melted snow, contains very little salt.

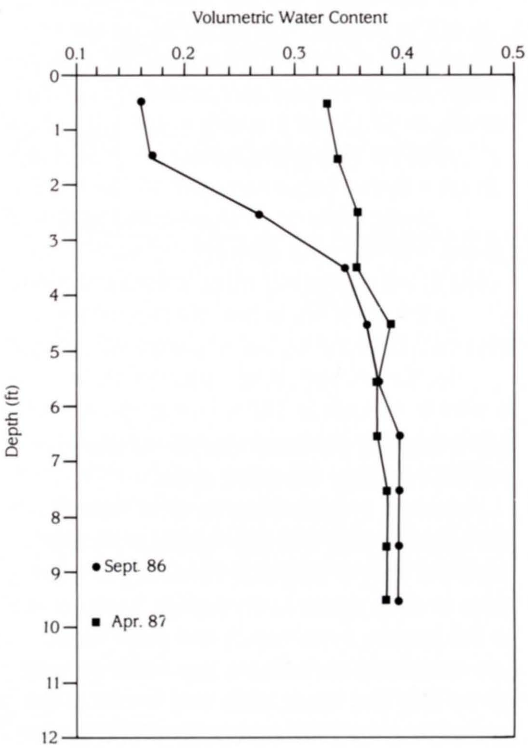
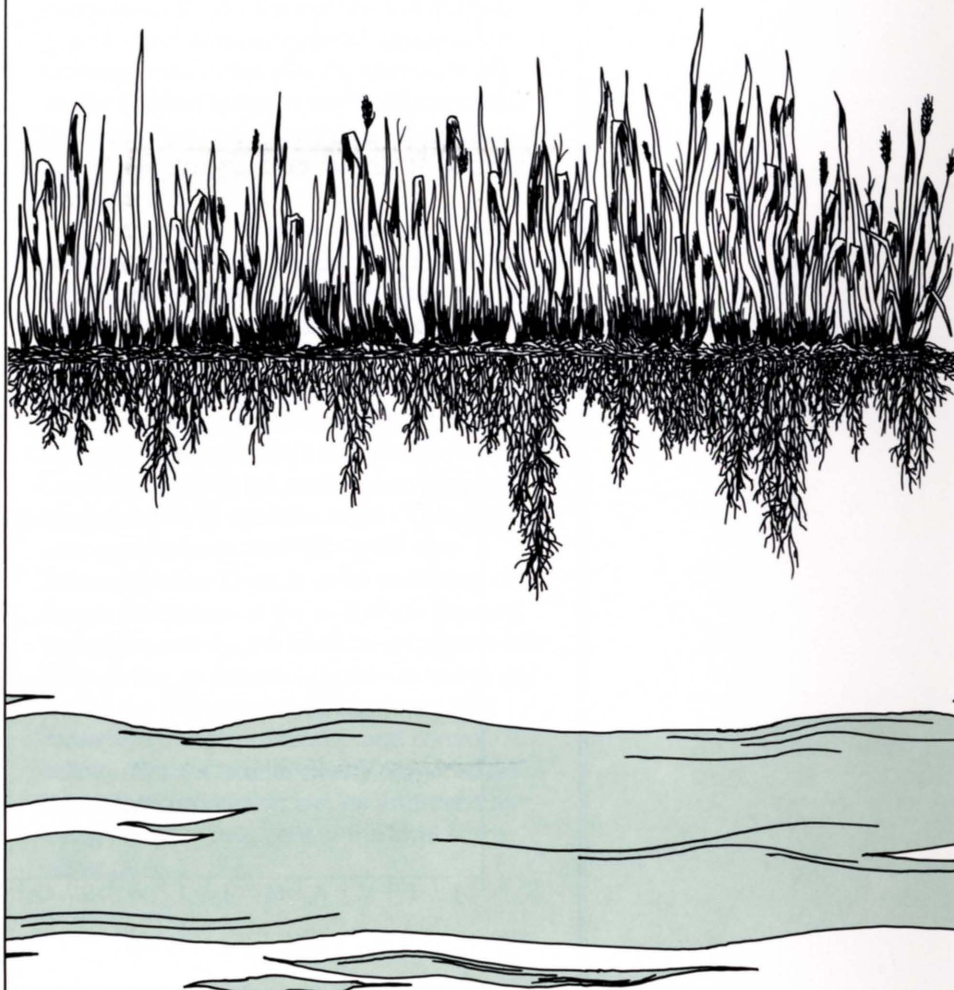


Figure 3. Volumetric soil water content versus depth, during September 1986 and April 1987.

Figure 3 shows the volumetric water content of the soil profile to a depth of 9.5 feet. The water content was high at the beginning of the 1986 growing season. The upper profile contained very little water in September 1986 because of root extraction and direct evapora-



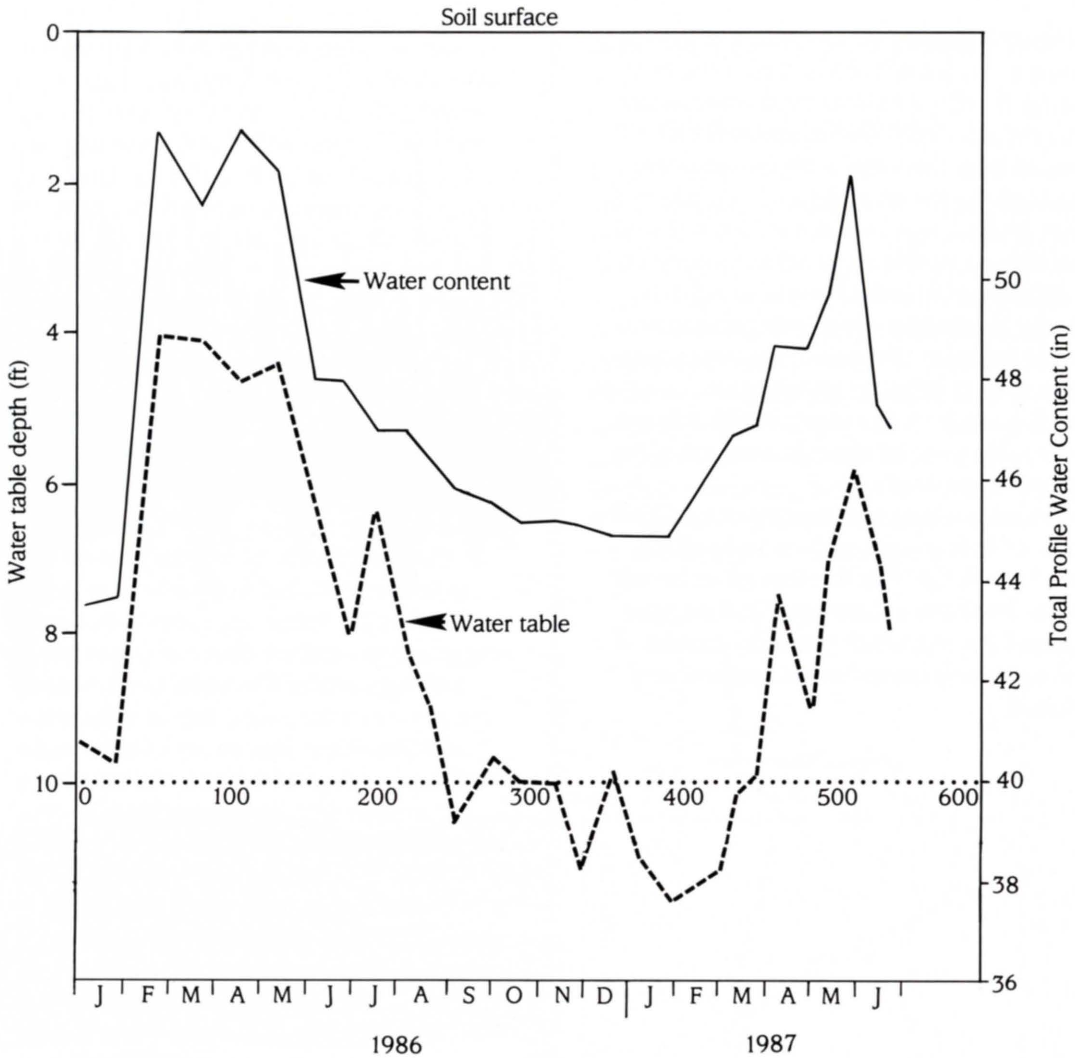


Figure 4. Variation in total soil water content and water table depth, 1986 and 1987.

tion. The lower soil profile contained more water, but the water content was constant because the water table was at about the same level.

Figure 4 shows the changes in position of the water table and the total water content of the soil profile to a depth of 9.5 feet from January 1986 through June 1987. Both the water table and the soil water content were low in January 1986. Warm weather and rain in February raised the water table to within 30 cm (1 foot) of the surface and increased the water content of the soil. Through March and April, the water table levels fluctuated and the water content of the soil dropped slightly. In May and June, the soil water content fell rapidly due to the vigorous grass growth. The level of the water table started to drop rapidly again when grass growth resumed after the first cutting. An irrigation in July increased the water content of the soil but did not raise the water table.

Following irrigation, plants used water in the upper profile and later extracted water from the deeper soil, thus causing the water table to drop again. Even though it rained late in the season, evaporation and plant water use continued to decrease the water content of the soil. The water table was lowest at the end of January 1987 and peaked in May due to snowmelt and rain. Both the water table and the water content of the soil water dropped rapidly in June, just before the first cutting.

A light irrigation, applied with a sprinkler system after the first cutting in July 1986, and rainfall increased the water content of the soil but did not reverse the decline in the water table. At the end of the season, the soil profile was dry, the water table was deep and the soil was ready to receive the winter precipitation that would wash salt downward.

Making sure that the soil is dry at the end of the season also allows animals to graze the last growth without mechanically damaging the soil and destroying plant roots.

Refining Water Management

Research at the Drainage Farm now concerns possible refinements to the system of water management to maximize production and avoid excessive salinity. Even though applying more water in the summer would increase forage production, salt might not leach deep in the profile during the winter unless the water table is deep. The risk of salinization increases if the soil is too wet at the end of summer. Salt is leached slowly even under the best of conditions and any changes in management must be carefully studied to ensure that they do not have adverse consequences. Research will also determine the reduction in forage production due to the need to keep the soil dry enough to lower the water table. Water management must occur during the active growing season since plants use little or no water during cold weather.

To date, the recommended practice is not to irrigate after August 1 to allow plants approximately 2 months to remove as much water as possible from the soil profile. If the soil profile was too wet at the end of the season, precipitation would not leach the salts downward and the salt in the deeper soil might work its way to the surface in as little as 3 years. Once the salt has leached downward, every effort should be made to keep it near the bottom of the root zone.

How long salt can be added to the soil profile depends on the salt content of the irrigation water and the type of salts. Careful water management can probably control salinity for many years if salts are derived mainly from gypsum and limestone. Some subsurface drainage may eventually be necessary on poorly drained irrigated soil. Soils at the USU Drainage Farm are poorly drained and salt has accumulated during the last 30 years of water control.

The change in location of the salt in the profile illustrates the beneficial reduction in salinity in the upper soil profile attainable by careful water management (Figure 1). The drainage and water management research conducted at the Drainage Farm demonstrates that salt in the soil profile of undrained low-lying pasture lands can be controlled by carefully applying irrigation water, thus making it possible to establish higher quality pasture grass species that will significantly increase yields. There is some reduction in forage production at the end of the growing season caused by the need to keep the water table as low as possible. Further research will define the management parameters that maximize forage production and control salinity. Results to date clearly demonstrate that forage production can be improved by using plants to help control the level of the water table.

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PRODUCING BEEF TO MEET CONSUMER NEEDS

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Americans have long enjoyed beef. In the early 1950s beef was the most popular red meat, a ranking it has since held almost continuously. Per capita annual consumption of beef was approximately 60 pounds (carcass basis) annually in the 1950s and 129 pounds in 1976. It is now approximately 80 pounds.

Beef producers and processors are concerned at this decrease in beef consumption and in the recent steady decline in the percentage of disposable income spent for beef, which peaked at 2.72 percent in 1976 and declined to 2.00 percent 1983, where it has remained.

The causes of these declines are only partially understood. Increases in the prices of gasoline, fuel, housing and medical care have reduced discretionary consumer income available to purchase beef. Lower prices for other meats, particularly poultry, have also contributed to this decline. Beef consumption has also declined because of the negative publicity concerning the adverse health effects of saturated fats and cholesterol.

Recent research indicates that beef, when included in a well-balanced diet, is not detrimental to health. Beef contains many beneficial nutrients. However, the typical American diet includes too much fat. More consumers are concerned about total fat intake, including intake of beef fat.

Under the present beef production system about 75 percent of the cattle are finished in feedlots where they are fed diets containing moderate to high amounts of concentrate. Cattle are fed until the majority of them appear to be fat enough to produce choice grade carcasses. Choice grade carcasses command 2 to 6 cents more per pound than good grade carcasses due to the widely accepted view that choice grade beef tastes better and is more tender than good grade beef that contains less fat.

This system means that large amounts of fat must be removed before beef is sold. The outer fat on steaks and roasts is now commonly trimmed to within 1/2 inch or less. This trimmed fat, which is expensive to produce, has little value.

The Utah Agricultural Experiment Station has cooperated with other western Stations in research concerning the production and marketing of beef. Much of the research is related to the problems reviewed above. In one of the studies, carcass cuts of beef from 1,280 steers, produced under controlled conditions, were marketed through seven grocery stores in Tucson, Arizona, and 28 grocery stores in San Antonio, Texas. Questionnaires were included with the retail beef cuts. Of these questionnaires, 9,786 were returned. The customers who purchased beef did not know the grade of beef or the treatment the steers had received. Some of the results of the studies are as follows:

Grain-Fed Beef Flavor

American consumers, in general, prefer grain-fed beef. However, results of our studies show that long periods of grain feeding and high levels of grain in the diet are not necessary for the desired grain-fed flavor. A grain feeding period of 80 to 100 days adds the desired grain-fed flavor to steers finished and slaughtered at 16-26 months of age.

Consumers' ratings of taste, tenderness and satisfaction indicated that there were no significant differences between beef from cattle whose diets contained various percentages of concentrates. Consumers gave similar ratings to beef from steers that received diets containing either 39, 52, 67 or 80 percent concentrates.

These results indicate that cattle need not be fed high-concentrate diets for long periods in order to produce beef that is satisfactory to the consumer.

Quality Grade

U.S.D.A. quality grades have been widely used in grading beef. Marbling is the major determinant of grade. There is more demand for choice grade beef over most of the United

TABLE 1. Percentage of consumers rating choice and good grade steaks as good or excellent.

Cattle group (age at start of test)		Taste		Tenderness		Satisfaction	
		Choice	Good	Choice	Good	Choice	Good
		%		%		%	
Loin and rib steaks	Calves #1[1]	84	89	87	84	92	88
	Calves #2	83	83	77	78	83	83
	Calves #3	83	75	78	74	84	79
	Yearlings #1	91	83	82	78	84	85
	Yearlings #2	86	77	70	67	81	77
Chuck steaks	Calves #1	84	90	84	84	90	89
	Calves #2	92	85	92	81	100	85
	Calves #3	89	89	81	87	87	90
	Yearlings #1	83	89	84	83	96	89
	Yearlings #2	86	85	78	77	84	86

[1]Numbers refer to replications during different years.

States, and choice grade beef supposedly has superior eating qualities to lower grades of beef. Our studies compared consumers' evaluations of choice and good grade beef. Consumers did not know the grade of the beef that they purchased. Table 1 shows the percentage of consuemrs that rated choice and good grade steaks as "good" or "excellent."

There were no statistically significant differences in the ratings for taste, tenderness or overall satisfaction between good and choice grade steaks. Good grade beef was as acceptable as choice grade to these consumers. The consumers in this study may not be representative of all American consumers. However, the seven food stores in Tucson and the 28 food stores in San Antonio were located throughout these cities and respondents probably represented diverse ethnic groups, various socioeconomic situations and various preferences. They probably represented a large segment of American consumers.

Management and Genetic Relationships

Decreasing the amount of marbling (intramuscular fat) required for a specific grade would result in less outside (subcutaneous) waste fat. Do some beef steers have the ability to acquire sufficient marbling while depositing only 1/2 inch or less of outside fat?

Our studies were not designed to adequately compare beef breeds or strains for this ability. However, differences in the characteristics of beef between the 12 strains included in this study suggest that selection and breeding could result in new lines of cattle that will, under new feeding and management systems, produce highly desirable, healthful beef without excessive outside fat.

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Two untrimmed choice-grade steaks: the steak on the left is characteristic of those produced several years ago; the amount of outside fat on the steak on the right is more acceptable to consumers. Most retail outlets trim additional outside fat.